# Abstract

*Photonic bandgap structures have provided promising platform for miniaturization of modern integrated optical devices. In this thesis, a photonic crystal based ring resonator (PCRR) is proposed and optimized to exhibit high quality factor. Also, force sensing application of the optimized PC ring resonator and Dense Wavelength Division Multiplexing (DWDM) application of the PCRR are discussed. Finally fabrication and characterization of the PCRR is presented.*

*A photonic crystal ring resonator is designed in a hexagonal lattice of air holes on a silicon slab. A novel approach is used to optimize PCRR to achieve high quality factor. The numerical analysis of the optimized photonic crystal ring resonator is presented in detail. For all electromagnetic computations Finite Difference Time Domain (FDTD) method is used.*

*The improvement in Q factor is explained by using the physical phenomenon, multipole cancellation of the radiation field of the PCRR cavity. The corresponding mathematical frame work has been included. The forced cancellation of lower order radiation components are verified by plotting far-field radiation pattern of the PCRR cavity.*

*Then, the force sensing application of the optimized PCRR is presented. A high sensitive force sensor based on photonic crystal ring resonator integrated with silicon micro cantilever is presented. The design and modeling of the device, including the*

*mechanics of the cantilever, FEM (Finite Element Method) analysis of the cantilever beam with PC and without PC integrated on it. The force sensing characteristics are presented for forces in the range of 0 to 1$\mu$N. For forces which are in the range of few tens of $\mu$N, a force sensor with bilayer cantilever is considered. PC ring resonator on the bilayer of 220nm thick silicon and 600nm thick $SiO_2$ plays the role of sensing element. Force sensing characteristics of the bilayer cantilever for forces in the range of 0 to 10$\mu$N are presented.*

*Fabrication and characterization of PCRR is also carried out. This experimental work is done mainly to understand practical issues in study of photonic crystal ring resonators. It is proved that Q factor of PCRR can be significantly improved by varying the PCRR parameters by the proposed method.*

*Dense Wavelength Division Multiplexing (DWDM) application of PC ring resonator is included. A novel 4-channel PC based demultiplexer is proposed and optimized in order to tolerate the fabrication errors and exhibit optimal cross talk, coupling efficiency between resonator and various channels of the device. Since the intention of this design is, to achieve the device performance that is independent of the unavoidable fabrication errors, the tolerance studies are made on the performance of the device towards the fabrication errors in the dimension of various related parameters.*

*In conclusion we summarize major results, applications including computations and practical measurements of this work and suggest future work that may be carried out later.*